STANDARD SUPPLEMENTAL SPECIFICATION NO. P-402

This supplemental specification augments and amends the specification of like number published in Federal Aviation Administration Advisory Circular 150/5370-10A, Standards for Specifying Construction of Airports, published February, 1989, and such subsequent changes as may be published to date.

SPECIFICATION NO. P-411, BITUMINOUS BASE, LEVELING AND TOP COURSES, is amended as follows:

Any references to 85-100 penetration grade or AC-10 viscosity grade in the scope of the work can be replaced by PG 58-28 binder.

Any references to 120-150 penetration grade or AC-5 viscosity grade in the scope of the work can be replaced by PG 58-28 binder.

Any references to 200-250 penetration grade or AC 2.5, viscosity grade in the scope of the work can be replaced by PG 58-28 binder.

"Performance Graded Asphalt Binder Specifications" follow on the next page.

Table I in the P-411 Standard Specification will not be used. Where Performance Graded Binders are used they shall meet the requirements as shown on the following page.

Approved: June 13, 1997
Revised: October 2, 1998

Performance Graded Asphalt Binder Specifications

Performance Grade	PG-52	PG-52	PG-58
	-28	-34	-28
Avg 7-day Max. Pave Design Temp, ^{0}C[a]	< 52	< 52	< 58
Minimum Pavement Design Temp. C[a]	> -28	> -34	> -28
Original Binder			
Flash Point Temp. T48: Min, ^{0}C	230		
Viscosity, ASTM D 4402;[b] Max. 3 Pa•s, Test Temp, ^{0}C	135		
Dynamic Shear, TP5;[c] G★/sin δ, Min. 1.00 kPa Test Temp @ 10 rad/s, ^{0}C	46	52	58
Rolling Thin Film Oven (T 240) or Thin Film Oven Residue (T 179)			
Mass Loss, Max. Percent	1.00		
Dynamic Shear, TP5; G★/sin δ, Min. 2.20 kPa Test Temp @ 10 rad/s, ^{0}C	46	52	58
Pressure Aging Vessel Residue (PP1)			
PAV Aging Temp. ^{0}C[d]	90	90	100
Dynamic Shear, TP5; G★ sin δ, Max. 5000 kPa Test Temp @ 10 rad/s, ^{0}C	16	13	19
Physical Hardening[e]			
Creep Stiffness, TP1'S, Max. 300 MPa, m-value, Min. 0300 Test Temp @ 60 s, ^{0}C	-18	-24	-18
Direct Tension, TP3;[f] Fail Strain, Min. 1.0% Test Temp 2 @ 1.0 mm/min, ^{0}C	-18	-24	-18

a: Pavement temperatures can be estimated from air temperatures using an algorithm contained in the Superpave™ software program or may be provided by the specifying agency, or by following the procedures as outlined in PPX.

b: This requirement may be waived at the discretion of the specifying agency if the supplier warrants that the asphalt binder can be adequately pumped and mixed at temperatures that meet all applicable safety standards.

c: For quality control of unmodified asphalt cement production, measurement of the viscosity of the original asphalt cement may be substituted for dynamic shear measurements of G★/sin δ at test temperatures where the asphalt is a Newtonian fluid. Any suitable standard means of viscosity measurement may be used, including capillary or rotational viscometer (AASHTO T 201 or T 202).

d: The PAV aging temperature is based on simulated climatic conditions and is one of three temperatures 90◦C, 100◦C or 110◦C. The PAV aging temperature is 100◦C for PG 64- and above, except in desert climates, where it is 100◦C.

e: Physical Hardening - TP 1 is performed on a set of asphalt beams according to Section 13.1 of TP 1, except the conditioning time is extended to 24 hours ± 10 minutes at 10◦C above the minimum performance temperature. The 24-hour stiffness and m-value are reported for information purposes only.

f: If the creep stiffness is below 300 MPa, the direct tension test is not required. If the creep stiffness is between 300 and 600 MPa, the direct tension failure strain requirement can be used in lieu of the creep stiffness requirement. The m-value requirement must be satisfied in both cases.

MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF AERONAUTICS - STANDARD SPECIFICATION
P-402
Porous Friction Course
(Central Plant Hot Mix)

DESCRIPTION

1.1 This item shall consist of an open-graded bituminous top course composed of mineral aggregate, bituminous material, and latex rubber mixed in a central mixing plant, and placed on a prepared surface in accordance with these specifications and shall conform to the dimensions shown on the plans.

MATERIALS

2.1 Aggregate. The aggregate shall consist of crushed stone, crushed gravel, or crushed slag with or without other inert finely divided mineral aggregate. The aggregate shall be composed of clean, sound, tough, durable particles, free from clay balls, organic matter, and other deleterious substances. The crushed aggregate portion which is retained on the 3/8-inch (9.5mm) sieve shall not contain more than 15 percent by weight of flat or elongated particles as defined in ASTM D693.

The crushed aggregate portion which is retained on the No. 4 (4.75mm) sieve shall not show a percentage of wear greater than 30 when tested in accordance with ASTM C131.

The crushed aggregate portion which passes the 3/4-inch (19.0mm) sieve and is retained on the No. 4 (4.75mm) sieve shall not show a total weighted average loss greater than 9 percent in sodium sulfate solution after 5 cycles when tested in accordance with ASTM C88.

The crushed aggregate portion passing the 3/4-inch (19.0mm) sieve and retained on the 1/4-inch (6.3mm) sieve shall have an estimated coated area "above 95 percent" when tested in accordance with ASTM D1664. If coated area is "below 95 percent," the asphalt shall be treated with an antistripping agent. The amount of antistripping agent used shall be sufficient to produce a coated area "above 95 percent."

If crushed gravel aggregate is used, that portion retained on the No. 8 (2.36mm) sieve and each succeeding coarser sieve shall contain at least 75 percent by weight of crushed pieces having two or more fractured faces and at least 90 percent by weight of particles containing one or more fractured faces. To count as a fractured face, the area of the fractured surface must be at least 75 percent of the smallest midsectional area of the particle being examined. To count as two fractured faces, the angle between two contiguous planes of fracture should be 30 degrees or more.

If crushed slag aggregates are used, the slag shall be air-cooled from the blast furnace process and shall have a compacted unit weight of not less than 70 pounds per cubic foot (1.12 Mg/cu.m) when tested in accordance with ASTM C29. Slag aggregate shall not be blended with natural aggregate.

2.2 Filler. If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D242. When flyash is used only MDOT approved sources will be permitted. When mineral filler is required to be batched separately, hydrated lime in the amount of 1.5 percent maximum by weight of the total aggregate shall be batched as part of the added mineral filler. No additional compensation will be allowed the Contractor for furnishing and using hydrated lime or other approved mineral filler that may be required by this specification.

2.3 Bituminous Material. The bituminous material shall conform to the requirements set forth in Table 1 and as specified herein.

2.4 Liquid Latex Additive. The rubber compound to be used in the bituminous mixture shall be an approved unvulcanized virgin synthetic rubber in liquid latex form. The manufacturer of the rubber compound shall provide a written certification which states the target value for total rubber solids content of the rubber compound. The certification shall also list actual test results which indicate material compliance with the following requirements:

Allowable Range of Target Value for Total Rubber Solids, % by Weight	45-72%
Allowable Variation from Target Value for Total Rubber Solids, % by Weight	± 1%
Ash, % of Total Rubber Solids, ASTM D297, Max.	3.5%
Viscosity, Brookfield Units, Model RVF, Spindle No. 2 at 20 rpm at 25°C, Max.	2000

FAA Approved: March 1, 1989

TABLE I.
PENETRATION-GRADED AND VISCOSITY-GRADED ASPHALT CEMENTS

TESTS	Asphalt Designations (Viscosity Graded in Parentheses)					
		85-100	120-150	200-250	250-300	
			-5)	(AC-2.5)		(AC-1)
Specific Gravity, 25/25c. min. ASTM D70			6	0.993		0.990
Viscosity, 25°C, P. max. ASTM D3205						120,000
*Viscosity, 60°C, P. ASTM D2171			-600	200-300		80-120
Viscosity, 135°C, cSt. min. ASTM D2170	300	220	165	120	120	75
Flash Point, Cleveland Open Cup, °C min. ASTM D92	232.2	232.2	218.3	204.4	204.4	204.4
Ductility, 25°C cm. min. ASTM D113	100	100	100	100**	100**	
Solubility in Trichloroethylene, % min. ASTM D2042	99.5	99.5	99.5	99.5	99.5	99.5
Spot Test using 35% Xylene 65% Heptane Solvent Aniline No. 30°C + 2 degrees AASHTO T102	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Thin Film Oven Test, 1/8 in. 163°C 5 hr. ASTM D1754:						
Loss on Heating, % max. ASTM D6	0.8	1.0	1.3	1.5	1.5	2.5
Penetration of Residue, % of original, min. ASTM D5	54	50	46	40	40	
Ductility of Residue, 25°C, 5 cm/min. cm. min. ASTM D113	50	75	100	100*	100*	100**
*Viscosity 60°C, P., max. ASTM D2171	8000	4000	2000	1000		800
Penetration 25°C. 100 g. 5 sec. ASTM D5:						
Penetration-Graded Asphalt Cement		85-100	120-150	200-250	250-300	
Viscosity-Graded Asphalt Cement	50-70	75-100	120-175	175-275		

* Viscosity-Graded Asphalts only

** If less than 100 at 25°C but more than 100 at 15.6°C, the material will be acceptable for ductility

The following compatibility tests shall be run on a sample of the latex to be delivered to the job site using a reference asphalt cement manufactured under the trade name Marathon, penetration grade 85-100.

For these compatibility tests the rubber asphalt cement mixture shall consist of three percent rubber solids by weight.

The rubber compound shall be compatible with the referenced asphalt such that the following properties are exhibited:

Softening Point, Degrees Centigrade Raise from Reference Asphalt, ASTM D36, Min. 8

Penetration at 25°C, 100g, 5 sec, mm/10 Drop from Reference Asphalt, ASTM D5 Min. 6

Penetration at 4°C, 200 g, 60 sec, mm/10
Increase from Reference Asphalt, ASTM D5, Min.. . . 1

Ductility, at 4°C, 1cm/min., ASTM D113±. . . . . 150±

Viscosity, Poises, 60° Minimum, ASTM D21210 . . . 2500

The rubber compound shall be compatible with the designated asphalt cement and aggregates such that the following properties are exhibited:

Dispersion of Rubber: Number of Remaining Black Rubbery Particles Visible to the Naked Eye . . . None

All of the above compatibility tests shall be performed and reported by the independent testing laboratory responsible for furnishing the job mix formula. The cost of these tests shall be incidental to the unit price of the bituminous mixture.

COMPOSITION

3.1 **Composition of Mixtures.** The porous friction course shall be composed of a mixture of aggregate, filler, bituminous material, liquid latex and anti-stripping agent (if required).

The aggregate fractions shall be sized, graded, and combined in the proportions that meet the requirements of the job mix formula.

The rubber-asphalt cement mixture shall consist of the percent rubber solids by weight, as specified on the construction drawings. The remainder of the mixture shall consist of asphalt cement at the penetration or viscosity grade indicated by the plans.

3.2 **Job Mix Formula.** No bituminous mixture shall be produced for payment until a job mix formula has been approved by the Project Engineer and reviewed by the Bureau. The testing laboratory used to develop the job mix formula shall meet the requirements of ASTM D3666 and shall be certified by the Bureau.

The job mix formula shall be submitted in writing by the Contractor to the Project Engineer at least 10 days prior to the start of paving operations and shall indicate the definite percentage of each sieve fraction of aggregate, the percentage of asphalt cement of the total mix, and the optimum mixing temperature. All test data used to develop the job mix formula shall also be submitted. The job mix formula for each mixture shall be in effect until modifications are approved by the Project Engineer. Should a change in sources of materials be made, a new job mix formula shall be established before the new material is used.

The asphalt cement content of the porous friction course shall be expressed as a percentage of the total mix by weight. It shall be determined by the mix design laboratory on the basis of laboratory tests of the aggregates the Contractor proposes to use and the bituminous material specified.

In order to determine the asphalt cement content you must first determine the surface capacity constant (K_c) of the coarse aggregate fraction passing the 3/8 in. (9.5 mm) sieve and retained on the No. 4 (4.75 mm) sieve by the Surface Capacity Test for Coarse Aggregate, a part of the Centrifuge Kerosene Equivalent (C.K.E.) Test. The K_c value, a measure of the relative roughness and degree of porosity of the aggregate, is used in an experience-based formula to calculate the design asphalt content.

The asphalt cement content shall be the value obtained from the following formula:

$$(2\ Kc^{+}\ 4.0)\ X\ \frac{2.65}{\text{Specific Gravity of Coarse Aggregate}}$$

Procedures for determining K_c are contained in Chapter IV of The Asphalt Institute's Manual Series No. 2 (MS-2). The asphalt cement content so determined is the percent by weight of the total dry aggregates and must be converted to the percent by weight of the total mix in the approved job mix formula.

The optimum mixing temperature is determined by observing the asphalt drainage from a sample of mixture maintained at temperatures in the range corresponding to temperatures at which the viscosity of the asphalt cement being used is 800± 100 centistokes. The test determines the recommended target mixing temperature at which the previously determined amount of asphalt cement may be used.

The optimum mixing temperature shall be between 300°F and 360°F and shall be determined using the following method:

> Prepare a 1000g sample of aggregate using the job mix gradation. Mix this sample at the asphalt cement content determined above with the latex content indicated on the plans. When completely coated, transfer the mixture to a pyrex glass plate (8-9 inch diameter) and spread the mixture with a minimum of manipulation. Return to the oven at the mixing temperature.

Observe the bottom of the plate after 15 and 60 minutes. A slight puddle at points of contact between aggregate and glass plate is suitable and desirable. Otherwise, repeat the test at a lower mixing temperature, or higher if necessary.

The purpose of the above test is not to determine asphalt cement content, but rather to determine the mixing temperature at which the recommended quantity of asphalt cement may be used.

If asphalt cement drainage occurs at a mixing temperature of 300°F the asphalt cement content may be reduced to a point at which drainage does not occur at 300°F, provided the asphalt content remains within the limits listed in Table 2.

The Contractor shall be responsible for the cost of the job mix formula, including the cost of providing materials for design and testing. Should an additional job mix formula be required due to extreme variations in mixture components supplied by the Contractor, the cost of such shall be at the Contractor's expense.

The combined aggregate shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the gradation shown in Table 2 when tested in accordance with ASTM C136. The range of asphalt cement content shown in Table 2 is representative of most crushed stone and crushed gravel aggregates and is not intended to limit the asphalt cement content established in the job mix formula.

The gradations in Table 2 represent the limits which shall determine the suitability of the aggregate for use from the sources of supply. The aggregate, as finally selected, shall have a gradation within the limits designated in Table 2 and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be uniformly graded from coarse to fine.

The job mix tolerance shown in Table 3 shall be applied to the job mix formula to establish a job control grading band. The full tolerances will still apply if applications of the job mix tolerances result in a job control grading band outside the master grading band.

If a change is made in any component of the bituminous mix, a new job mix formula shall be approved by the Project Engineer before any additional material on the project is produced and placed. When unsatisfactory results or other conditions make it necessary, the Project Engineer may establish a new job mix formula.

TABLE 2

AGGREGATE - POROUS FRICTION COURSE

Sieve Size	Percentage by Weight Passing Sieves	
	3/4 in. Maximum	1/2 in. Maximum
3/4 in. (19.0 mm)	100	–
1/2 in. (12.5 mm)	70 - 100	100
3/8 in. (9.5 mm)	45 - 75	80 - 100
No. 4 (4.75 mm)	20 - 40	20 - 40
No. 8 (2.36 mm)	12 - 12	12 - 20
No. 30 (600 micro m)	8 - 14	8 - 14
No. 200 (75 micro m)	3 - 5	3 - 5
Compacted Thickness:	1 in. (25 mm)	3/4 in. (19mm)
Asphalt Cement Content: 5-7 percent by weight of total mix		

TABLE 3.

JOB MIX FORMULA TOLERANCES
(Based on a Single Test)

Material	Tolerance + or -
Aggregate Passing No. 4 Sieve or Larger	7.0 Percent
Aggregate Passing No. 8 and No. 30 Sieves	4.0 Percent
Aggregate Passing No. 20 Sieve	2.0 Percent
Asphalt Cement Content	0.40 Percent
Temperature of Mix	20°F (11°C)

3.3 Test Section. Prior to full plant production, the Contractor shall prepare a quantity of porous friction course mixture according to the job mix formula. The amount of mixture should be sufficient to construct a test section of at least 400 feet long and 20 feet wide. The test area will be designated

by the Project Engineer. The mixture shall be placed in two sections and shall be of the same depth specified on the plans. The underlying pavement on which the test section is to be constructed shall be the same as the remainder of course represented by the test section. The equipment to be used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section.

If the test section should prove to be unsatisfactory, the necessary adjustments to the mix design, plant operation, and/or rolling procedures shall be made. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. When test sections do not conform to specification requirements, the pavement shall be removed and replaced at the Contractor's expense. Full production shall not begin without approval of the Project Engineer. Test sections will be paid for in accordance with Paragraph 6.1.

CONSTRUCTION METHODS

4.1 **Weather and Seasonal Limitations.** The porous friction course shall be constructed only on a dry surface when the atmospheric temperature is 50°F (10°C) and rising (at calm wind conditions) and when the weather is not foggy or rainy.

4.2 **Addition of Latex.** In batch plants, the latex rubber compound shall be added to the pugmill approximately 10 seconds after the addition of the asphalt cement.

In drum plants the latex rubber compound shall be added at a point after the aggregate has been coated with asphalt cement but at a distance from the discharge end of the drum adequate to insure thorough mixing.

The use of surge bins for the storage of bituminous mixtures will be permitted. The maximum time material may be stored in a surge bin is 30 minutes. If drainage of the asphalt from the mixture occurs during the use of the surge bin, the time allowed for storage shall be reduced until drainage of the rubber-asphalt binder is stopped.

The latex modifier handling equipment shall be capable of precisely metering and uniformly distributing the latex into the asphalt mixture. The latex modifier insertion system shall be calibrated during each day of use in order to verify the output rate is matched with the plan production rate within the specified tolerance.

4.3 **Bituminous Mixing Plant.** The bituminous mixing plant shall include all facilities or equipment necessary to produce the bituminous mix. The facility shall include auxiliary items such as stockpile storage areas, equipment to construct and maintain the stockpiles, cold bin or silo storage, and the feeder system from the cold bin or silo storage to the drier(s).

Plants used for the preparation of bituminous mixtures shall conform to all requirements under (a), except that scale requirements shall apply only where weight proportioning is used. In addition, batch mixing plants shall conform to the requirements under (b), and continuous mixing plants shall conform to the requirements under (c).

(a) Requirements for All Plants. Mixing plants shall be of sufficient capacity to adequately produce the quantity of bituminous mixture for the proposed construction.

(1) Aggregate Stockpiles. Sufficient storage space shall be provided so that each aggregate size can be kept in separate stockpiles. The stockpile will be constructed in uniform layers by using a clamshell or other approved method to prevent segregation. The use of bulldozers in stockpiling aggregates will not be permitted. The storage yard shall be neat and orderly, and the separate stockpiles shall be readily accessible for sampling.

(2) Cold Bins. The plants shall have an adequate number of cold bins or silos for each aggregate size. These cold bins or silos shall be constructed so that no overflow from one bin to the other occurs. They shall also have individual, adjustable outlet devices to provide a uniform and continuous flow of materials in the desired proportions. Prior to producing any mixture, the Contractor shall furnish the Project Engineer with calibrations showing the rate of feed of each aggregate for the cold bin or silo in which it is to be used. Change of material or change of cold bin or silo will require new calibrations. The calibration shall show the rate of feed per minute per unit of opening or setting of feed.

(3) Feeder for Drier. The plant shall be provided with accurate mechanical means for uniformly feeding the aggregate into the drier to obtain uniform production and temperature.

(4) Drier. The plant shall include a drier(s) which continuously agitates the aggregate during the heating and drying process.

(5) Screens. Plant screens, capable of screening all aggregates to the specified size and proportions and having normal capacities in excess of the full capacity of the mixer, shall be provided.

(6) Dust Collector. The plant shall be equipped with a dust collector to waste any material or to return all or any part of the material uniformly to the mixture as directed.

(7) Hot Bins. The plant shall include hot bins of sufficient capacity to supply a mixer operating at full capacity. Hot bins shall be arranged to assure separate and adequate storage of appropriate fractions of the aggregates. When used, separate dry storage shall be provided for batching mineral filler and hydrated lime. The plant shall be equipped to proportion and feed the material into the mixer. Each bin shall be provided with overflow pipes located to prevent backup of material in other compartments or bins. Each compartment shall be provided with its individual outlet gate to prevent leakage. The gates shall cut off quickly and completely. Hot bins shall be constructed so that samples may be obtained readily. Hot bins shall be equipped with adequate telltale devices which indicate the position of the aggregates in the bins at the lower quarter points.

(8) Plant Scales. Scales shall be accurate to 0.5 percent of the required load. Poises shall be designed to be locked in any position to prevent unauthorized change of position. In lieu of plant scales, the Contractor may provide an approved automatic printer system to print the weights of the material delivered, provided the system is used in conjunction with an approved automatic batching and mixing control system. Such weights shall be evidenced by a weigh ticket for each load. Scales shall be inspected for accuracy and sealed as often as the Project Engineer may deem necessary. The Contractor shall have on hand not less than ten 50-pound (23 kg) weights for testing the scales.

(9) Equipment for Preparation of Bituminous Material. Tanks for the storage of bituminous material shall be equipped to heat and hold the material at the required temperatures. Heating shall be accomplished by approved means so that flames will not contact the tank. The circulating system for the bituminous material shall be designed to assure proper and continuous circulation during the operating period. Provision shall be made for measuring quantities and for sampling the material in the storage tanks.

(10) Bituminous Control Unit. Satisfactory means, either by weighing of by metering, shall be provided to obtain the specified amount of bituminous material in the mix. Means shall be provided for checking the quantity or rate of flow of bituminous material into the mixer.

(11) Thermometric Equipment. An approved thermometer of adequate range shall be placed in the bituminous feed line at a suitable location near the discharge valve of the mixer unit. The plant shall also be equipped with an approved thermometric instrument placed at the discharge chute of the drier to indicate the temperature of the heated aggregates.

(12) Safety Requirements. Adequate and safe stairways to the mixer platform and sampling points shall be provided. Guarded ladders to other plant units shall be placed at all points where accessibility to plant operations is required. Accessibility to the top of truck bodies shall be provided by a suitable device to enable the Project Engineer to obtain mixture samples and temperature data. A means shall be provided to raise and lower scale calibration equipment, sampling equipment, and other similar equipment between the ground and the mixer platform. All belts, gears, pulleys, chains, sprockets, projecting setscrews, keys, and other dangerous moving parts shall be guarded to prevent inadvertent contact by workmen or other moving equipment. Ample and unobstructed passage shall be maintained at all times in and around the truck loading area. This area shall be kept free of drippings from the mixing platform.

(13) Truck Scales. The bituminous mixture shall be weighed on approved scales furnished by the Contractor or on public scales at the Contractor's expense. Scales shall be inspected for accuracy and sealed as often as the Project Engineer deems necessary.

(b) Requirements for Batching Plants.

(1) Weight Box or Hopper. The equipment shall include a means for accurately weighing each size of aggregate in a weight box or hopper of ample size to hold a full batch without hand raking or running over. The [illegible] shall close tightly so that no material is allowed to leak into the mixer while a batch is being weighed.

(2) Bituminous Control. The equipment used to measure the bituminous material shall be accurate to within plus or minus 0.5 percent. The bituminous material bucket shall be of a nontilting type with a loose sheet metal cover. The length of the discharge opening of the spray-bar shall not be

less than three-fourths the length of the mixer, and it shall discharge directly into the mixer. The bituminous material bucket, its discharge valve(s), and the spray-bar shall be adequately heated. Steam jackets, if used, shall be efficiently drained, and all connections shall be constructed so that they will not interfere with the efficient operation of the bituminous scales. The capacity of the bituminous material bucket shall be at least 15 percent of the weight of bituminous material required in any batch. The plant shall have an adequately heated, quick-acting, nondrip charging valve located directly over the bituminous material bucket.

The indicator dial shall have a capacity of at least 15 percent in excess of the quantity of bituminous material used per batch. The controls shall be constructed to lock at any dial setting and automatically reset to that reading after each additional batch of bituminous material. The dial shall be in full view of the mixer operator. The flow of bituminous material shall be automatically controlled to begin when the dry mixing period is over. All of the bituminous material required for one batch shall be discharged in not more than 15 seconds after the flow has begun. The size and spacing of the spray-bar openings shall provide a uniform application of bituminous material the full length of the mixer. The section of the bituminous line between the charging valve and the spray-bar shall have a valve and an outlet for checking the meter when a metering device is substituted for a bituminous material bucket.

(3) Mixer. The batch mixer shall be an approved type capable of producing a uniform mixture with well-coated aggregate in the prescribed mixing time within the job mix tolerance specified. If not enclosed, the mixer box shall be equipped with a hood to prevent loss of dust.

(4) Control of Mixing Time. The mixer shall be equipped with an accurate time lock to control the operations of a complete mixing cycle. It shall lock the weigh-box gate after the charging of the mixer and keep it locked until the closing of the mixer gate at the completion of the cycle. It shall lock the bucket throughout the dry mixing period and shall lock the mixer gate throughout the dry and wet mixing periods. The dry mixing period is the time interval between the opening of the weigh-box gate and the introduction of the bituminous material. The wet mixing period is the time interval between the introduction of the bituminous material and the opening of the mixer gate.

The timing control shall be flexible and shall be capable of settings at 5-second intervals or less throughout a 3-minute cycle. A mechanical batch counter shall be installed as a part of the timing device and shall be designed to register only completely mixed batches.

The setting of time intervals shall be at the direction of the Project Engineer who shall then lock the case covering the timing device. It shall remain locked until a change is made in the timing periods.

(c) Requirements for Continuous Plants.

(1) Aggregate Proportioning. The plant shall include means for accurately proportioning each size of aggregate.

The plant shall have a feeder mounted under each compartment bin. Each compartment bin shall have an accurately controlled individual gate to form an orifice for the volumetric measuring of material drawn from each compartment. The feeding orifice shall be rectangular with one dimension adjustable by positive mechanical means and provided with a lock.

Indicators shall be provided for each gate to show the respective gate opening in inches.

(2) Weight Calibration of Aggregate Feed. The plant shall include a means to calibrate gate openings by weighing test samples. Provision shall also be made so that materials fed out of individual orifices may be bypassed to individual test boxes. The plant shall be equipped to conveniently handle individual test samples of not less than 200 pounds (92 kg). Accurate scales shall be provided by the Contractor to weigh such samples. Charts showing the rate of feed per minute for each hot bin shall be provided.

(3) Synchronization of Aggregate Feed and Bituminous Materials Feed. A satisfactory interlocking mechanical means or any other positive method approved by the Project Engineer shall be provided to afford positive interlocking control between the flow of aggregate from the bins and the flow of bituminous material from the meter or other proporti ..... device.

(4) Mixer. The plant shall include an approved continuous mixer adequately heated and capable of producing a uniform mixture within the job mix tolerances. It shall be equipped with a discharge hopper with dump gates to permit rapid and complete discharge of the mixture. The paddles shall be adjustable for an angular position mix. The mixer shall have a manufacturer's plate giving the

net volumetric contents of the mixer at the several heights inscribed on a permanent gauge and the rate of feed of aggregate per minute at plant operating speed. Unless otherwise required, the minimum mixing time shall be determined by dividing the weight of its contents at operating level by the weight of the mixture delivered per second by the mixer.

The weights for the job will be determined by tests made by the Project Engineer. The pugmill shall be equipped with a discharge hopper having a capacity of approximately one ton (900 kg). The hopper will be equipped with dump gates which will permit rapid and complete discharge of the bituminous mixture without segregation.

4.4 Hauling Equipment. Trucks used for hauling the bituminous mixture shall have tight, clean, smooth beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of concentrated hydrated lime and water solution. The truck beds shall be raised to drain any excess solution before loading the mixture in the trucks. Each truck shall have a suitable cover to protect the mixture from adverse weather or long hauls. An insulated bed may be required to maintain the mixture at the specified temperature during hauling.

4.5 Bituminous Pavers. Bituminous pavers shall be self-contained, power propelled units with an activated screed or strike-off assembly, heated if necessary, and shall be capable of spreading and finishing courses of bituminous plant mix material which will meet the specified thickness, smoothness, and grade.

The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed. The screed or strike-off assembly shall produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

The paver shall be capable of operating at forward speeds consistent with satisfactory laying of the mixture.

If an automatic grade control device is used, the paver shall be equipped with a control system capable of automatically maintaining the screed elevation as specified herein. The control system shall be automatically actuated from either a reference line or a surface through a system of mechanical sensors or sensor-directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface.

4.6 Rollers. A minimum of two self-propelled, steel-wheel rollers shall be furnished. They shall be in good condition, capable of operating at slow speeds to avoid displacement of the bituminous mixture. The wheels shall be equipped with adjustable scrapers, water tanks, and sprinkling apparatuses to prevent the bituminous mixture from sticking to the wheels. The weight of each roller shall be six to 12 tons (5,400 to 10,800 kg). The use of equipment which results in excessive crushing of the aggregate will not be permitted. Liquid detergent shall be added to the water to prevent the mix from sticking to steel wheels.

4.7 Preparation of Mineral Aggregate. The aggregate for the mixture shall be dried and heated at the central mixing plant before entering the mixer. When introduced into the mixer, the combined aggregate moisture content (weighed according to the composition of the blend) shall be less than 0.25 percent for aggregate blends with water absorption of 2.5 percent or less and less than 0.50 percent for aggregate blends with water absorption greater than 2.5 percent. Water absorption of aggregates shall be determined by ASTM C127 and ASTM C128. The water absorption for the aggregate blend shall be the weighed average of the absorption values for the coarse aggregate retained on the No. 4 sieve (4.75 mm) and the fine aggregate passing the No. 4 sieve (4.75 mm). The water content test will be conducted in accordance with ASTM C566. In no case shall the moisture content be such that forming of the mixture occurs prior to placement. At the time of mixing, the temperature of the aggregate shall be within the range specified in the job mix formula. The maximum temperature and rate of heating shall be such that no damage occurs to the aggregates. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by overheating. The aggregate shall be screened to specified sizes and conveyed in separate bins ready for mixing with bituminous material.

4.8 Preparation of Bituminous Mixture. The bituminous mixture shall be prepared in a central mixing plant.

The dry aggregate shall be combined in the plant in the proportionate amounts of each aggregate size required to meet the specified gradation. The quantity of aggregate for each batch shall be determined, measured, and conveyed into the mixer. In case of volumetric proportioning, the size of the

openings shall be determined, and the gates shall be locked in position.

The quantity of bituminous material for each batch or the calibrated amount for continuous mixers shall be determined by the Project Engineer. It shall be measured by weight and introduced into the mixer within the temperature range specified in the job mix formula. For batch mixers, all aggregates shall be in the mixer before the bituminous material is added. In no case shall the temperature of the aggregate be more than 25°F (14°C) above the temperature of the bituminous material when adding the bituminous material. As determined by the Project Engineer, the mixing shall continue until all particles are coated uniformly.

4.9 Transportation and Delivery of the Mixture. The mixture shall be transported from the central mixing plant to the paving job in trucks described in Paragraph 4.4. The mixture shall be placed at the target temperature derived from the job mix formula ±20°F. Delivery of the mixture shall be scheduled so that spreading and rolling of a day's production can be completed during daylight hours the same day.

4.10 Spreading and Laying.

(a) Preparation of Existing Surfaces. All porous friction courses shall be constructed on an existing pavement surface that is structurally sound; is in good condition; is constructed to new pavement surface course smoothness criteria; and has Marshall stability and flow values comparable to those specified in Specification P-411. The work involved in rehabilitating the existing pavement surface shall be otherwise provided for in the contract and is not a part of this porous friction course specification. Rehabilitation of the existing pavement including: construction of bituminous overlay; joint sealing; crack repair; reconstruction of failed pavement areas; removal of rubber deposits; removal of pavement markings; and cleaning of grease, oil, and fuel spills shall be completed and accepted by the Project Engineer prior to the placement of the porous friction course.

Immediately before placing the porous friction course, the underlying course shall be cleared of all loose or deleterious material with power blowers, power brooms, or hand brooms as directed. A tack coat conforming to Specification P-603 shall be placed, as directed by the Project Engineer, on those existing surfaces where a tack coat is necessary for bonding the porous friction course to the existing surface. If emulsified asphalt is used, placement of the porous friction course can be applied immediately. However, if cutback asphalt is used, placement of the porous friction course must be delayed until the tack coat has properly aired.

(b) Placing. Hauling over material already placed shall not be permitted until the material has been thoroughly compacted as specified and allowed to develop its stability for a period of, at least, 12 hours. In areas where extremely hot temperatures occur, it is suggested that no traffic be allowed on the porous friction course until it has cooled overnight. Traffic should be discontinued if any closing of the porous friction course is observed. The bituminous mixture shall be placed at the required minimum lane width with an approved bituminous paver as specified in Paragraph 4.5.

4.11 Compaction of Mixture. After spreading the mixture shall be thoroughly and uniformly compacted with power rollers. Rolling of the mixture shall begin as soon after spreading as it will bear the roller without undue displacement or hair-checking. Rolling shall be initiated with the drive wheel toward the paving machine. The sequence of rolling the first paving lane should be to first roll the lower edge (with reference to the transverse slope) of the lane and then to roll the upper edge. The interior of the lane should then be rolled from the lower side toward the upper edge with overlapping roller paths. On adjoining paving lanes, rolling shall begin by overlapping the joint (with the previous lane) by six to nine inches (15 to 23 cm) and then rolling the outside edge of the new lane. The interior should be rolled from the outside edge toward the compacted joint with overlapping wheel paths. Alternate trips of the roller shall be of slightly different lengths. The number of passes with a steel-wheel roller shall be as determined by the test section. The optimum weight of the roller shall also be determined during test section construction.

The speed of the roller shall be slow enough to avoid displacement of the hot mixture. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once by raking and applying fresh mixture.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until all roller marks are eliminated and the surface is of uniform texture and conforms to the required cross section.

To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened, but excessive water will not be permitted.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers.

Any mixture which becomes loose and broken, mixed with dirt, or in any way defective, shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work will be done at the Contractor's expense. Skin patching and handworking of the porous friction course mixture will not be allowed.

4.12 Joints. The formation of all joints shall be made in such a manner as to ensure a continuous bond between old and new sections of the course. All joints shall present the same texture, density, and smoothness as other sections of the course.

The roller shall not pass over the unprotected end of the freshly laid mixture except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course, in which case the edge shall be cut back to its full depth and width on a straight line to expose vertical face. In both methods all contact surfaces shall be given a tack coat of bituminous material before placing any fresh mixture against the joint.

Longitudinal joints which are irregular, damaged, or otherwise defective shall be cut back to expose a clean, sound surface for the full depth of the courses. All contact surfaces shall be given a tack coat of bituminous material prior to placing any fresh mixture against the joint. The longitudinal joint shall offset that in the existing course by at least one foot (30 cm).

4.13 Shaping Edges. While the surface is being compacted and finished, the Contractor shall carefully shape the longitudinal outside edges of the porous friction course to a vertical face at the established edge. When transitioning from porous friction course to existing pavement, transverse edges shall be constructed with a finer graded bituminous mixture.

4.14 Surface Tests. After completion of the final rolling, the finished surface shall be tested with a 16-foot (5 m) straightedge and shall not vary more than 1/4 inch (6 mm). The 16-foot (5 m) straightedge shall be applied parallel with and at right angles to the runway centerline in a pattern that includes longitudinal and transverse joints. The 16-foot (5 m) straightedge shall be advanced approximately 1/2 its length in the line of measurement.

Areas of the porous friction course exceeding the specified tolerances shall be corrected at the Contractor's expense by removing the defective work and replacing it with new material. Skin patching or handworking will not be permitted.

4.15 Sampling Porous Friction Course Mixture and Hot Bins. Samples of the porous friction course mixture shall be taken at the point of discharge in hauling units and tested to control uniformity in the bituminous content and gradation. Samples shall be taken in accordance with ASTM D979. Enough mixture shall be taken to prepare duplicate tests on each sample of mixture in accordance with ASTM D2172. Samples shall be taken, at least, once, for any central plant-run of more than 30 minutes and at least twice for any central plant-run of more than five hours.

Should the bituminous content of the duplicate tests agree within 0.50 percent, the average results shall be recorded. Variations greater than 0.50 percent between duplicate tests of the same sample shall also be recorded, and duplicate tests on an additional sample shall be run. The average value of the bituminous content should fall within the tolerance of the job mix formula as specified in Paragraph 3.2. Should the average bituminous content for four samples not fall within the job mix tolerances, the Project Engineer may order the Contractor to cease production until such out-of-tolerance conditions have been remedied by the Contractor. The gradation of the residual aggregate should be determined by using AASHTO T30 and compared to the approved job mix formula.

The samples of porous friction course mixture will be used to control the uniformity of the Contractor's plant production. In addition, the Contractor shall clearly mark each hauling unit from which the representative samples have been taken so that the same mixture sample may be located in the completed pavement.

Completed porous friction course shall be determined "acceptable" or "unacceptable" on the basis of visual inspection by the Project Engineer. The Project Engineer shall immediately notify the Contractor of visual defects such as nonuniform texture, roller marks, bleeding of bituminous material, cracking and shoving of the mixture, and evidence of aggregate crushing during the roller operations, or nonconformance to the surface smoothness criteria as specified in Paragraph 4.14.

"Unacceptable" porous friction course shall be removed, leaving a vertical face at the remaining porous friction course. The underlying surface shall be cleaned and a tack coat applied prior to replacing

the porous friction course. All work shall be at the Contractor's expense. Unacceptable porous friction course shall not be measured for payment.

In addition to sampling and testing the porous friction course mixture, the Project Engineer shall sample each hot bin twice daily and furnish a gradation analysis of each hot bin according to ASTM C136. The combined gradation analysis of the hot bins shall fall within the job mix formula tolerances. Should the hot bin gradation analysis fail to meet the tolerances of the job mix formula (on the same sieve size), the Project Engineer may order another analysis in addition to the two analyses required each day to confirm the results of the previous tests or tell the Contractor to cease plant production until such out-of-tolerance conditions have been corrected.

4.16 Bituminous and Aggregate Material (Contractor's Responsibility). Samples of the bituminous and aggregate materials that the Contractor proposes to use, together with a statement of their source and character, shall be submitted for approval prior to use. The Contractor shall require the manufacturer or producer of the bituminous and aggregate materials to furnish material subject to this and all other pertinent requirements of the contract. Only those materials which have been tested and approved for the intended use shall be acceptable.

The Project Engineer or his/her authorized representative shall have access, at all times, to all parts of the paving plant to inspect the equipment, the conditions, and the operation of the plant; to verify the weights or proportions and character of materials; and to determine the temperatures maintained in the storage of the bituminous material and preparation of the mixtures.

The Contractor shall furnish the vendor's certified test reports for each carload or equivalent of bituminous material shipped to the project. The report shall be delivered to the Project Engineer before permission is granted to use the material. The vendor's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance.

All test reports shall be subject to verification by testing sample materials received for use on the project.

4.17 Protection of Pavement. After final rolling, no vehicular traffic of any kind shall be permitted on the pavement until it has cured at least 12 hours. Newly constructed pavement areas shall not be opened to aircraft traffic until 24 hours after completion or unless otherwise authorized by the Project Engineer.

METHOD OF MEASUREMENT

5.1 Porous friction course shall be measured by the number of tons of mixture used in the accepted work.

Only areas of the porous friction course meeting the thickness requirements of Table 4 shall be measured for payment.

TABLE 4.

ALLOWABLE FINISHED POROUS COURSE THICKNESS

	Nominal		Maximum		Minimum	
	in.	mm	in.	mm	in.	mn
3/4 in. Aggregate	1.0	25	1.50	37	0.75	19
1/2 in. Aggregate	0.75	19	1.25	32	0.50	12

To determine the thickness of the finished porous friction course, the Contractor shall take one core sample, at locations determined by the Project Engineer, not less than 2 inches (5 cm) in diameter, at random from each unit of the completed porous friction course area. A unit of completed porous friction course area is 10,000 square yards of pavement.

When the measurement of any core is more than the maximum or less than the minimum allowable thickness, as shown in Table 4, additional cores shall be taken at 20-foot intervals (6 m parallel to and at right angles to the runway centerline) until the completed porous friction course is within such maximum or minimum thickness for the subunit being tested. Out-of-tolerance areas shall be deducted from the total tons porous friction course for payment. If, in the Project Engineer's judgment, such out-of-tolerance areas warrant removal, the porous friction course shall be removed and the underlying course shall be cleaned (ready for reconstruction), all at the Contractor's expense.

BASIS OF PAYMENT

6.1 Payment shall be made at the respective contract prices per ton for porous friction course. The prices shall be full compensation for furnishing all materials; for all preparation and storage of materials; for cleaning the existing surface; for mixing, hauling, placing, and compacting the mixture (including initial test section); and for all tools, equipment, and incidentals necessary to complete each item. No separate payment is included in the

contract for furnishing and batching mineral filler, or antistripping agents, should such items be required.

Rehabilitation of the existing pavement surface and tack coat shall be measured and paid for at their respective contract prices.

Payment will be made under the nomenclature and seven digit item number specified in the plans and proposal for porous friction course work required per ton. The first three digits of any item number for work included under this specification shall be 402, i.e., 402XXXX.

TESTING REQUIREMENTS

ASTM C29	Unit Weight of Aggregate
ASTM C88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C127	Specific Gravity and Absorption of Fine Aggregate
ASTM C131	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
ASTM C136	Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C566	Total Moisture Content of Aggregate by Drying
ASTM C128	Specific Gravity and Absorption of Fine Aggregate
ASTM D693	Crushed Stone, Crushed Slag, and Crushed Gravel for Bituminous Macadam Base and Surface Courses of Pavements
ASTM D979	Sampling Bituminous Paving Mixtures
ASTM D2172	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
AASHTO T30	Mechanical Analysis of Extracted Aggregate
ASTM D1664	Coating and Stripping of Bitumen-Aggregate Mixtures

MATERIAL REQUIREMENTS

ASTM D242	Mineral Filler for Bituminous Paving Mixtures
*ASTM D946	Asphalt Cement for Use in Pavement Construction
**ASTM D3381	Viscosity-Graded Asphalt Cement for Use in Pavement Construction
AASHTO T102	Spot Test of Asphaltic Materials
ASTM D70	Specific Gravity of Semi-Solid Bituminous Materials
ASTM D3205	Viscosity of Asphalt with Core and Plate Viscometer
ASTM D2170	Viscosity
ASTM D6	Loss on Heating of Oil and Asphalt Compounds
ASTM D297	Percent of Total Rubber Solids
ASTM D36	Softening Point of Asphalts and Tar Pitches (Ring-and-Ball Apparatus)

* Penetration Graded Asphalts only

** Viscosity Graded Asphalts only